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Kobori

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(54) **VALVE DEVICE FOR EXHAUST GAS FLOW PATH**

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USPC 137/527, 527.6
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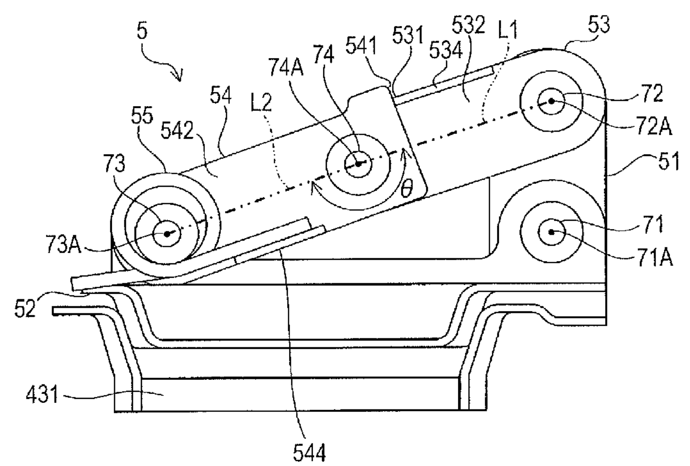
(57) **ABSTRACT**

A valve device includes a butterfly valve and a first link member each supported by a stay so as to be rotationally movable about a first rotation axis and a second rotation axis, respectively, a second link member supported by the butterfly valve so as to be rotationally movable about a third rotation axis, and a spring to bias the butterfly valve in a valve closed direction. The first link member and the second link member are connected to each other so as to be mutually rotationally movable about a fourth rotation axis. An angle formed by a first link line connecting the second rotation axis and the fourth rotation axis to each other and a second link line connecting the third rotation axis and the fourth rotation axis to each other is formed to be the largest when the butterfly valve is in a valve closed state.

17 Claims, 9 Drawing Sheets



(51) **Int. Cl.**
F01N 1/08 (2006.01)
F16K 15/03 (2006.01)

(52) **U.S. Cl.**
CPC ***F01N 1/165*** (2013.01); ***F01N 1/166*** (2013.01); ***F01N 1/18*** (2013.01); ***F16K 15/033*** (2013.01); *F01N 2240/36* (2013.01); *F01N 2290/10* (2013.01); *Y10T 137/7898* (2015.04)

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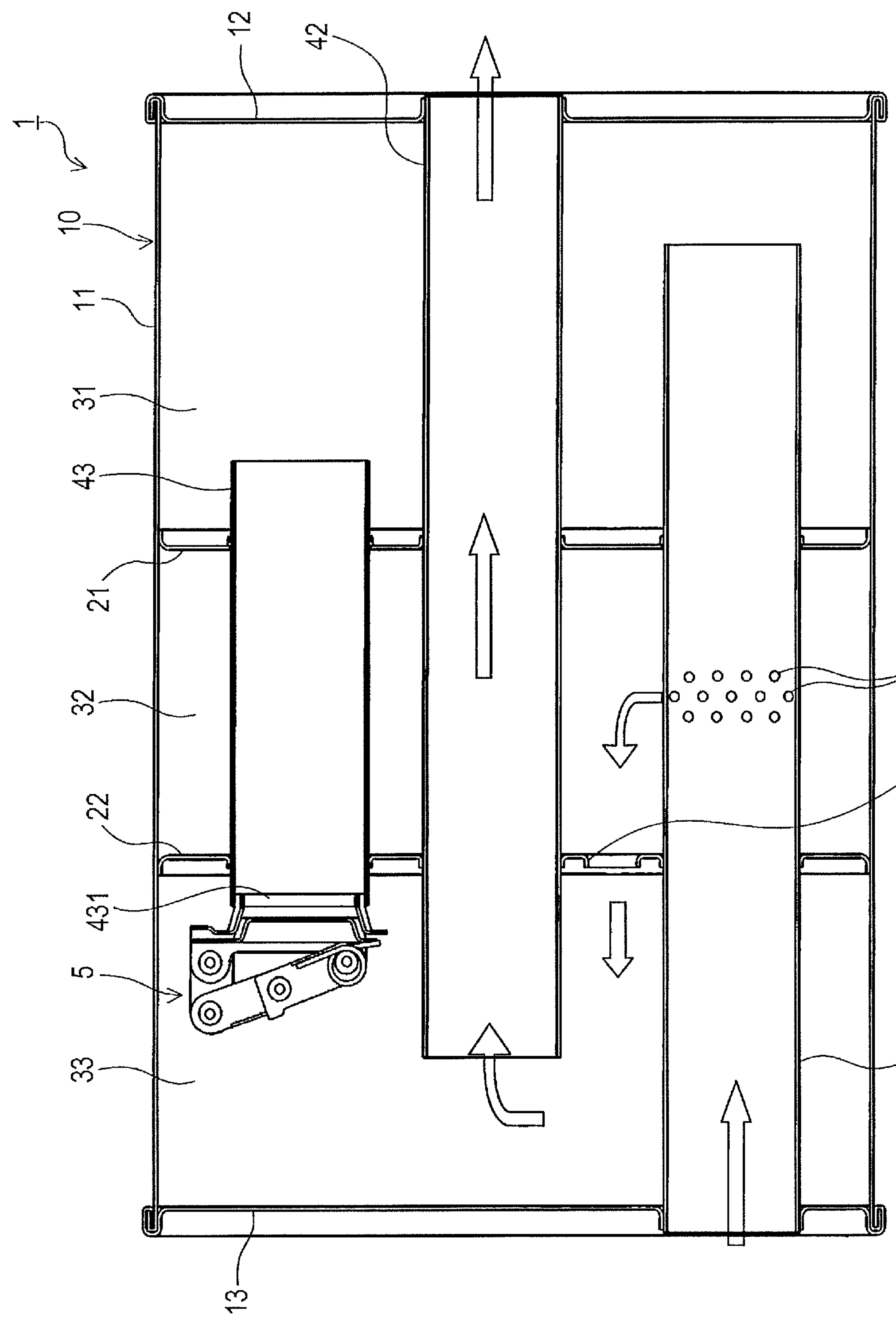


FIG.1

FIG.2A

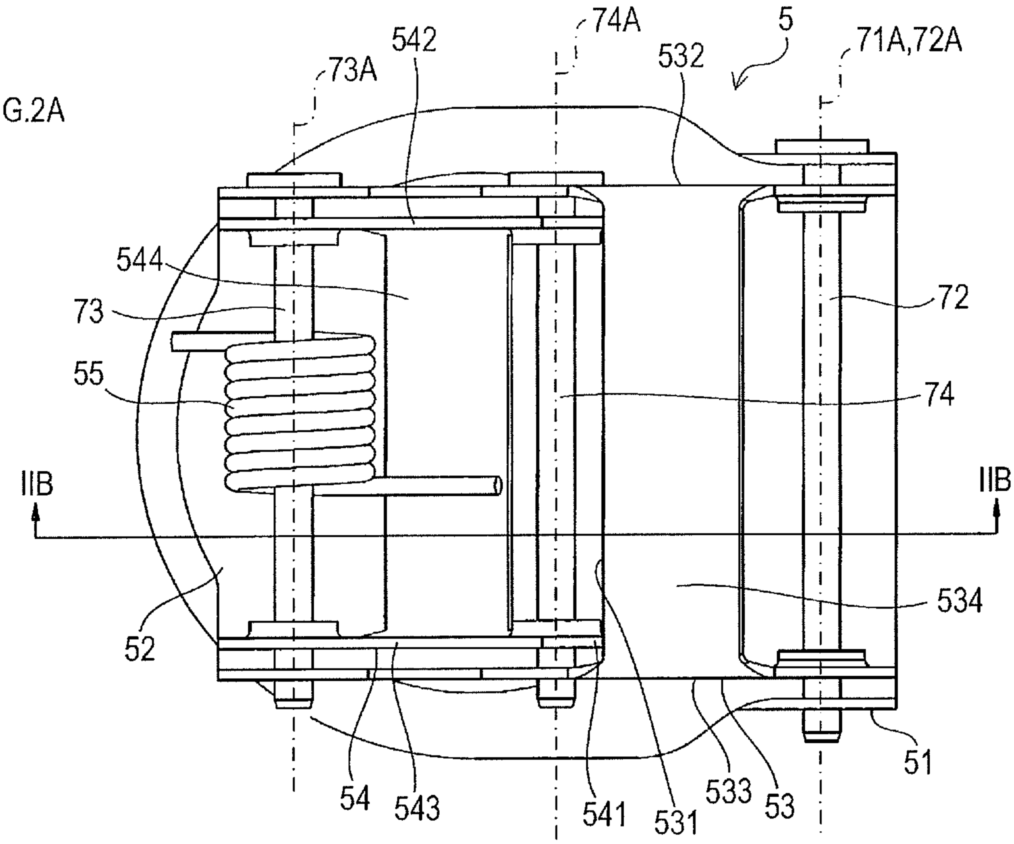

74A
5
542
532
71A,72A
73A
544
73
72
55
74
IIB
IIB
534
52
51
54
543
541
531
533
53

FIG.2B

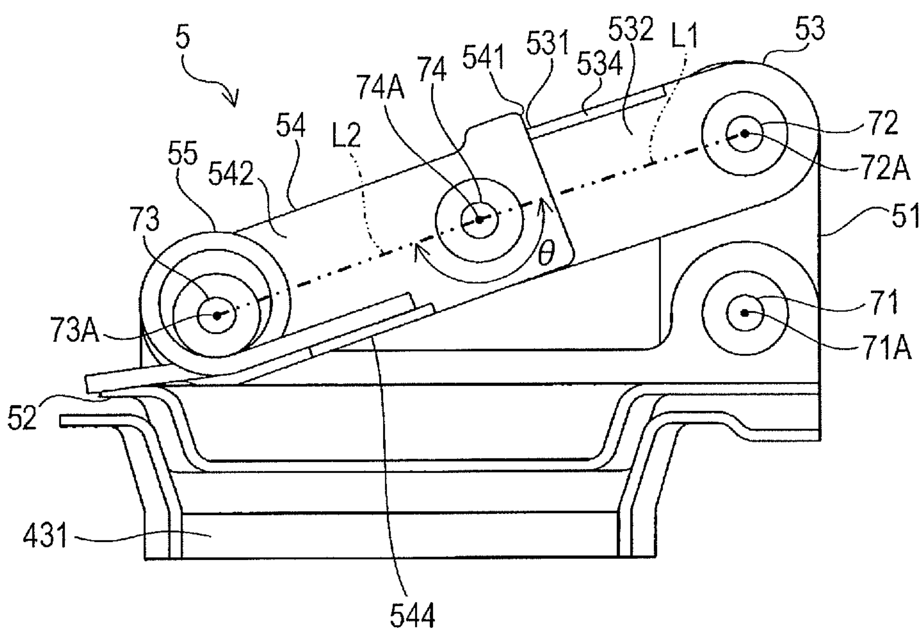
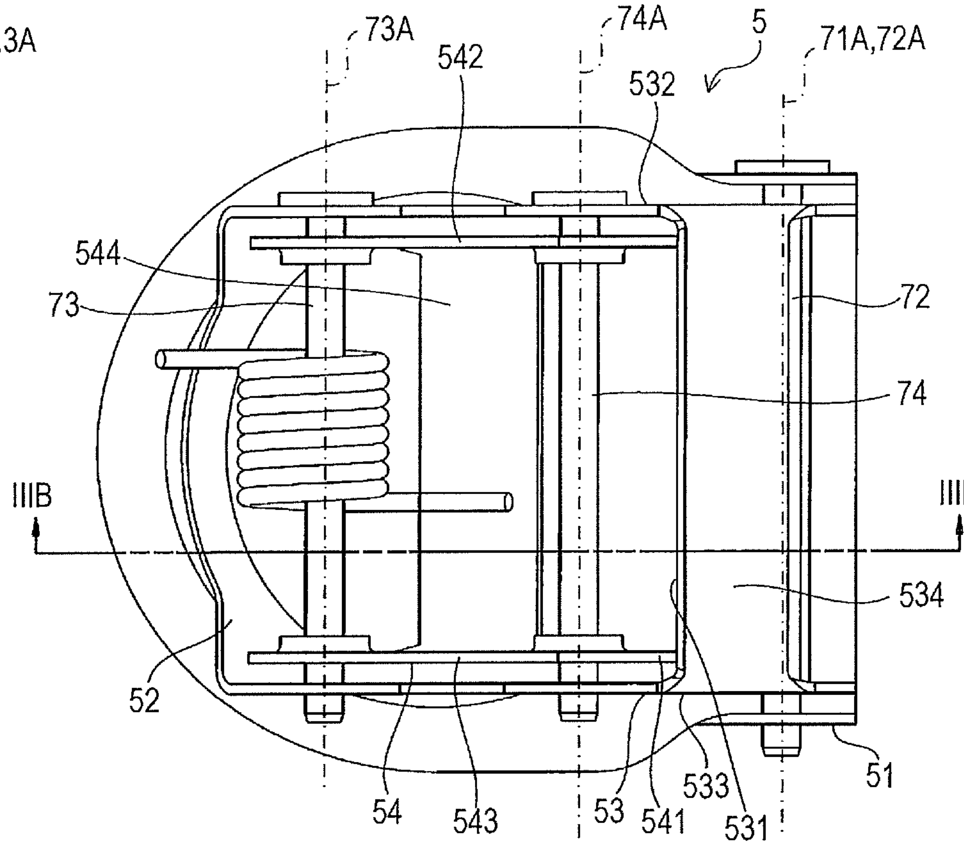

53
532
L1
531
534
541
74
74A
5
54
L2
72
55
542
72A
51
73
θ
71
73A
71A
52
431
544

FIG.3A


73A
74A
5
71A,72A
542
532
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74
IIIB
IIIB
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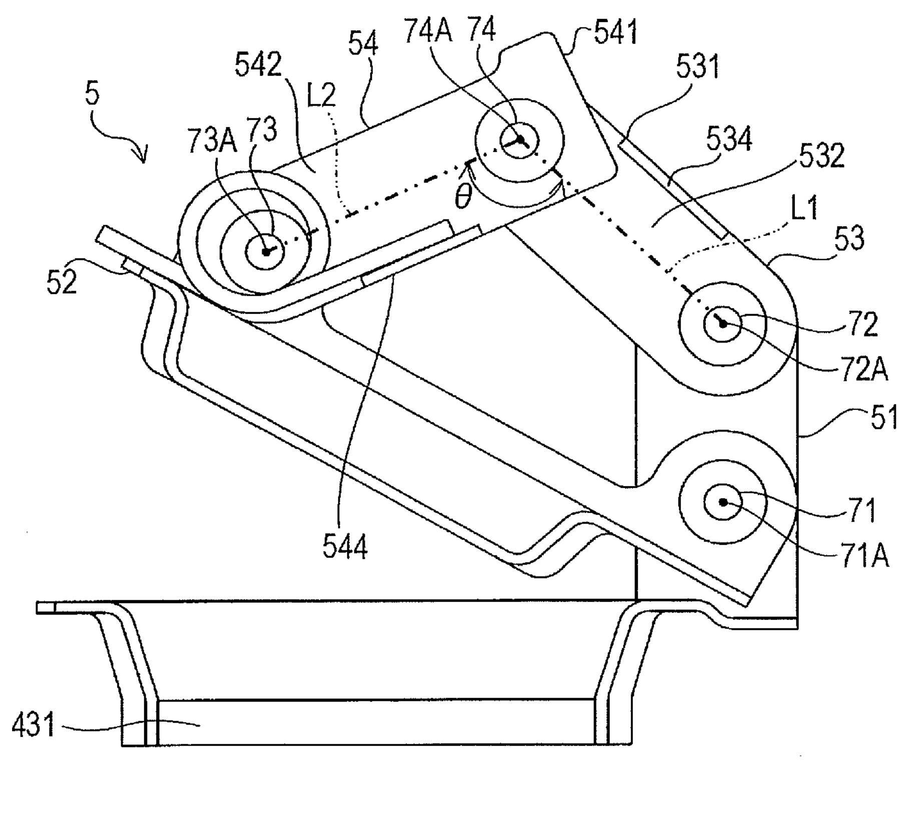
541
533
531

FIG.3B


542
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74A
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71A
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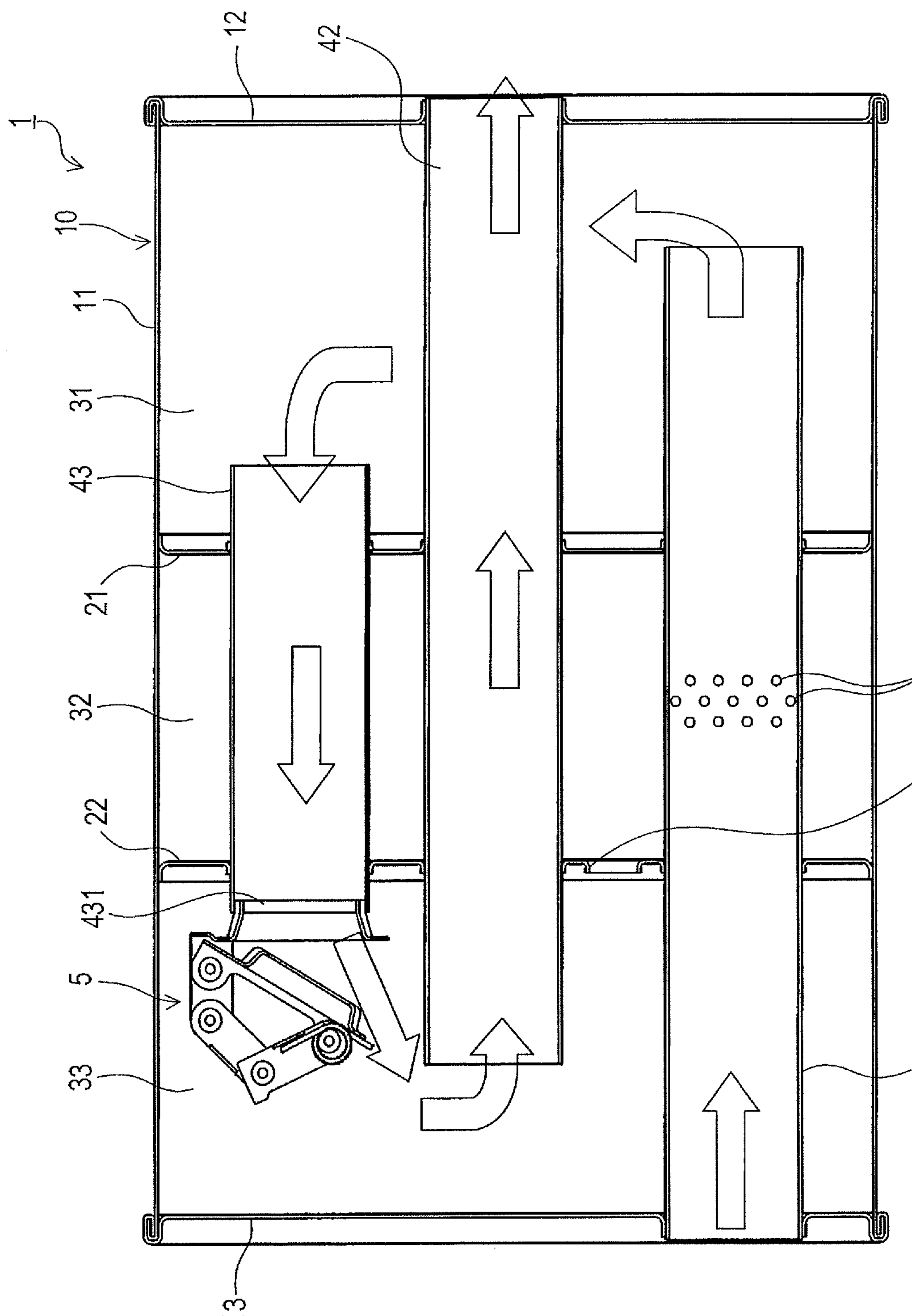


FIG.4

FIG.5A

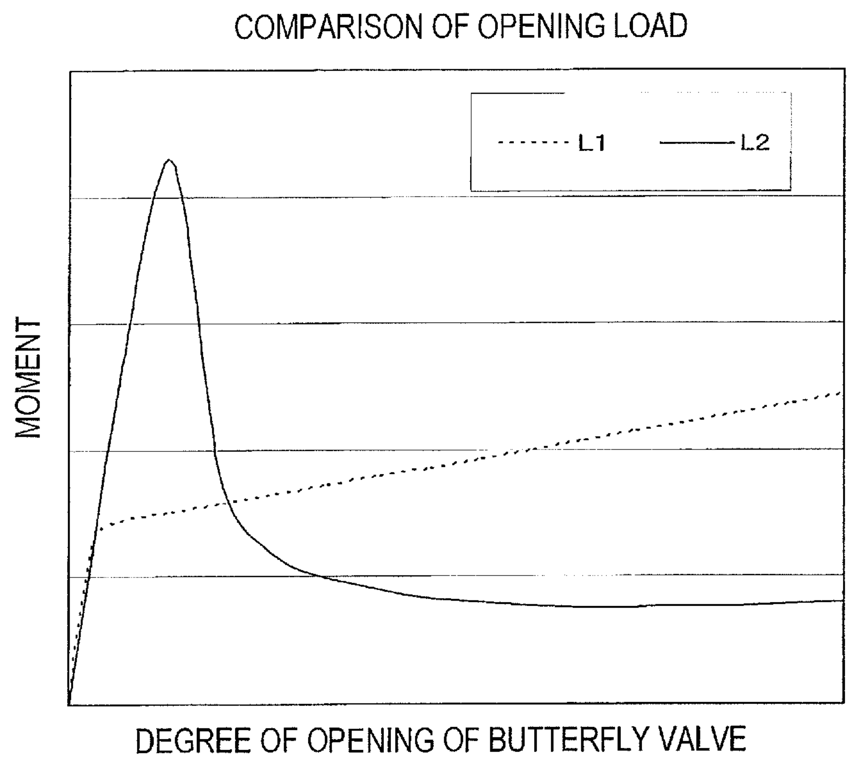

COMPARISON OF OPENING LOAD
L1
L2
MOMENT
DEGREE OF OPENING OF BUTTERFLY VALVE

FIG.5B

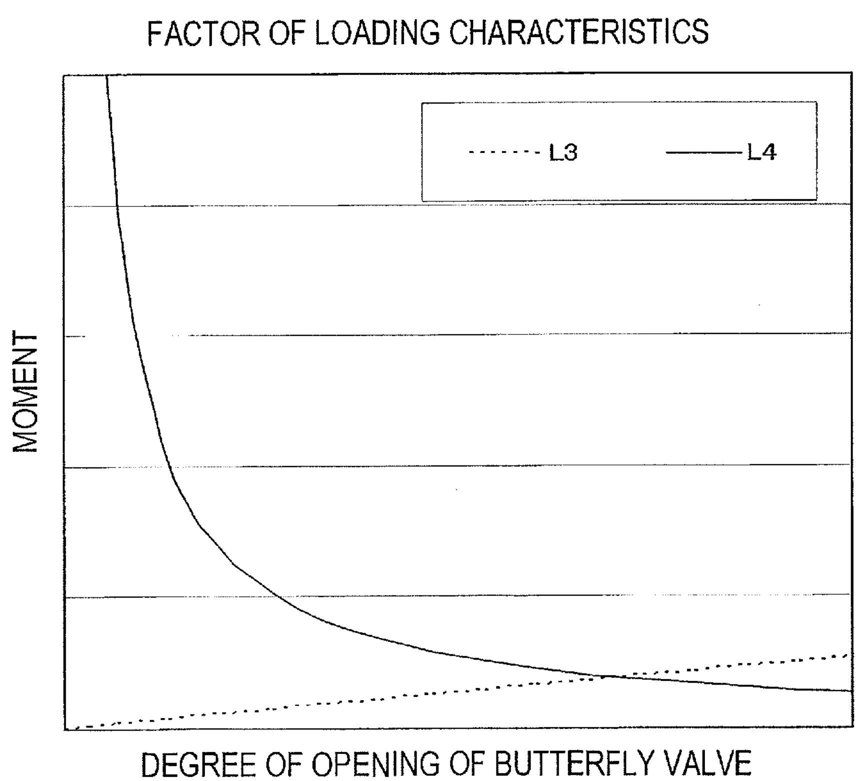
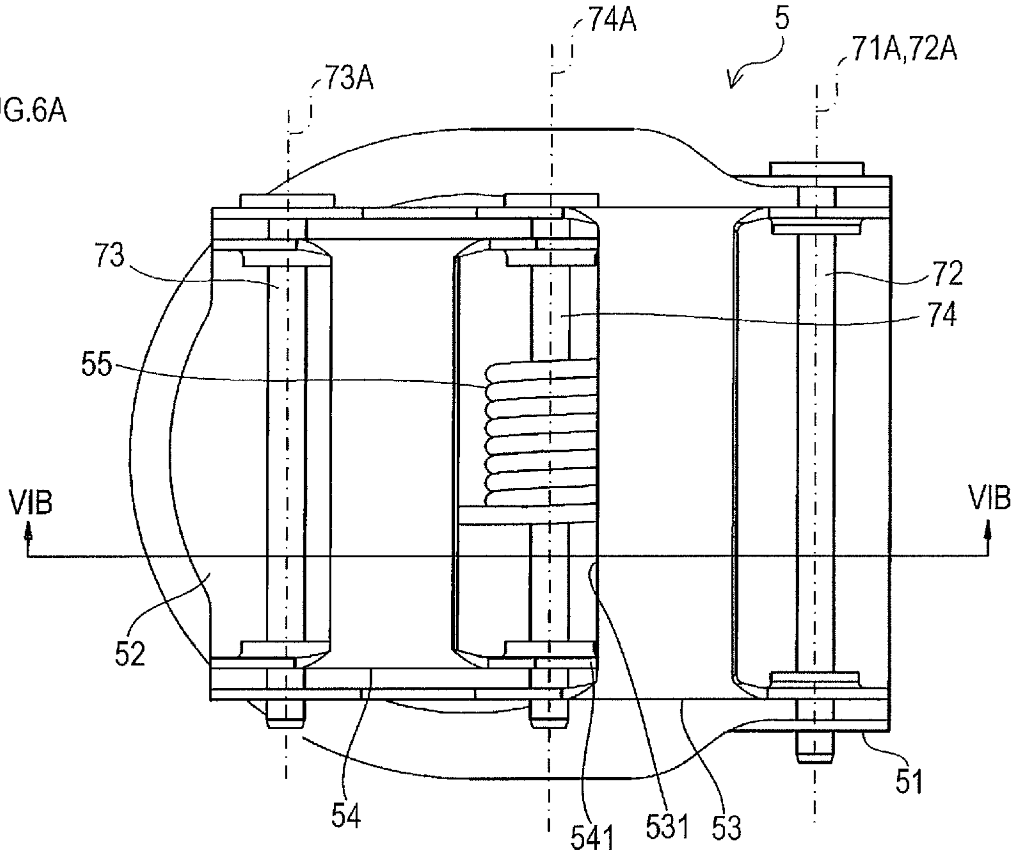

FACTOR OF LOADING CHARACTERISTICS
L3
L4
MOMENT
DEGREE OF OPENING OF BUTTERFLY VALVE

FIG.6A


74A
5
71A,72A
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73
72
74
55
VIB
VIB
52
54
541
531
53
51

FIG.6B

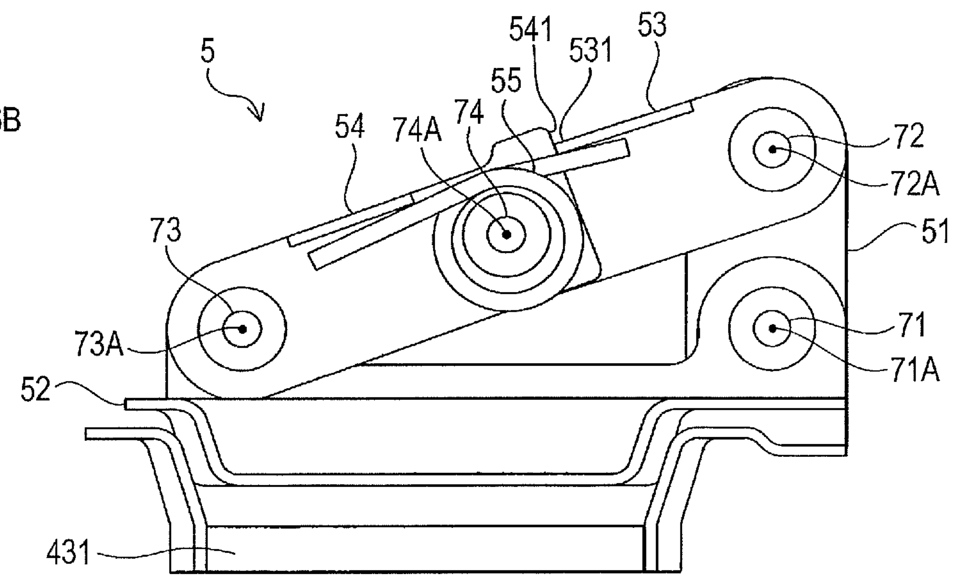
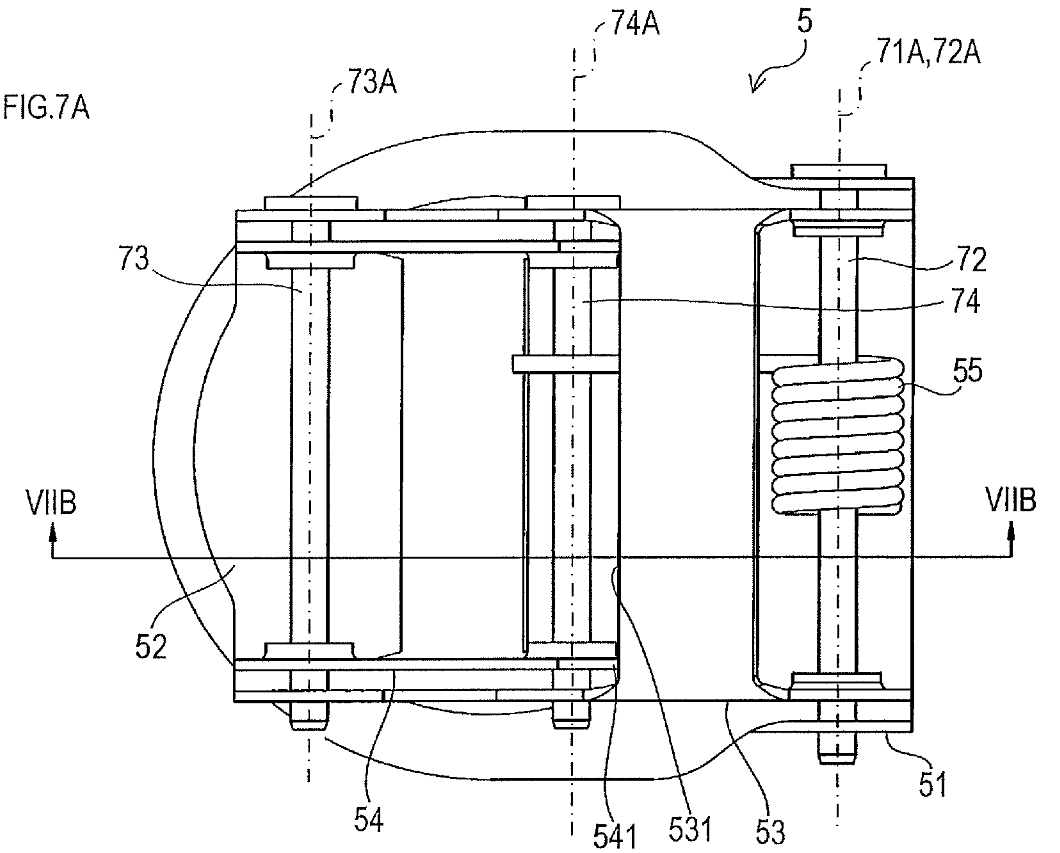

5
541
531
53
55
54
74A
74
72
72A
73
51
73A
71
71A
52
431

FIG.7A


74A
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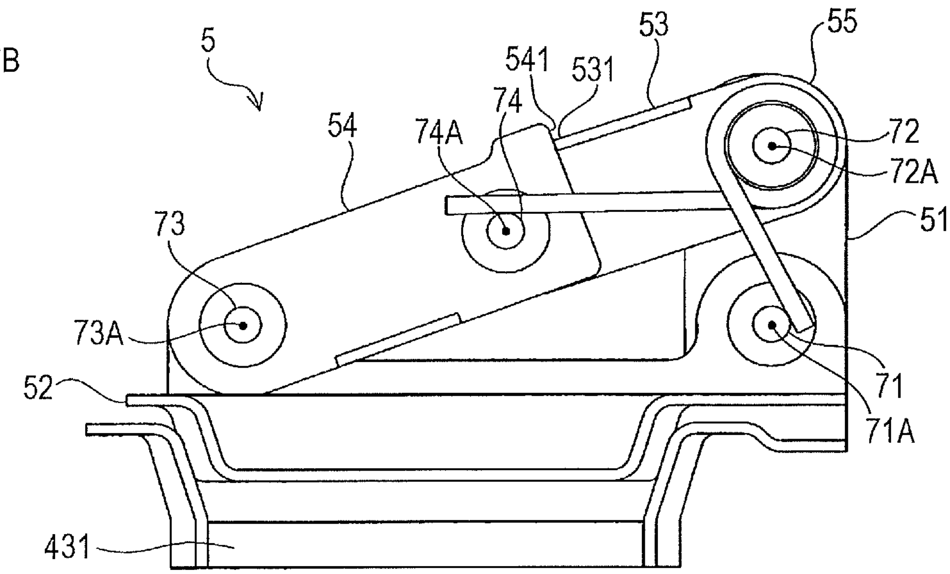
72
74
55
VIIB
VIIB
52
54
541
531
53
51

FIG.7B


5
541
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74
74A
72
72A
73
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73A
52
71
71A
431

FIG.8A

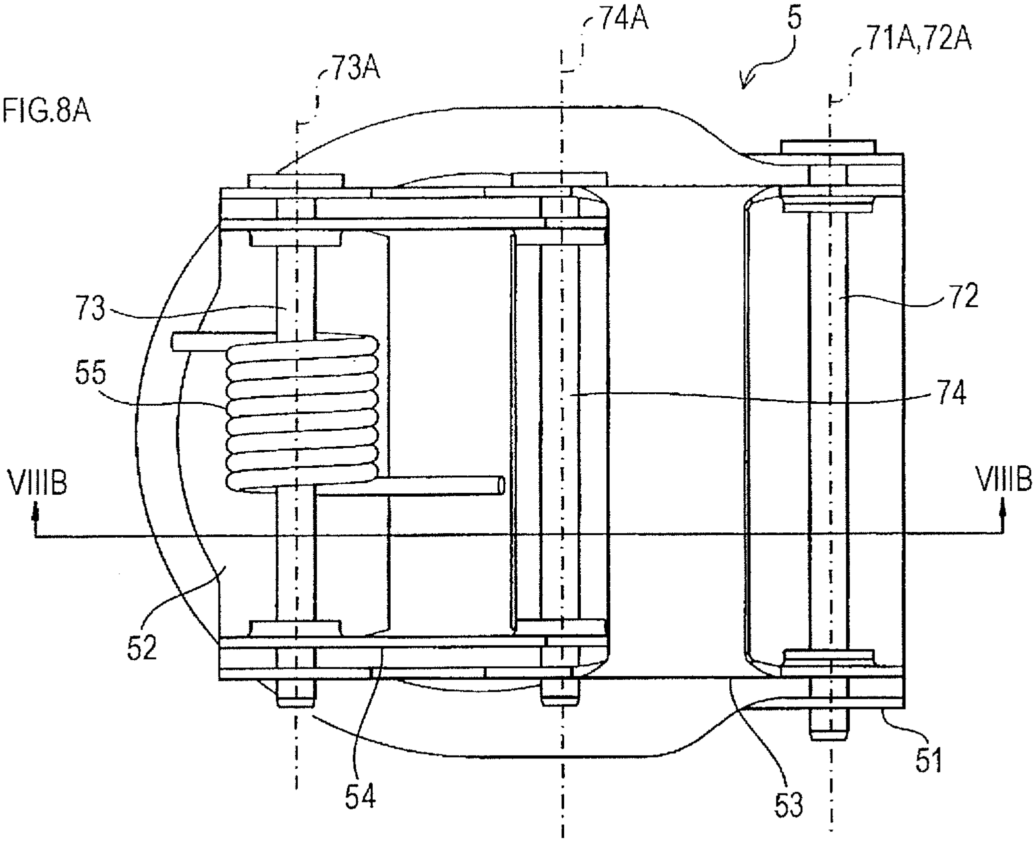
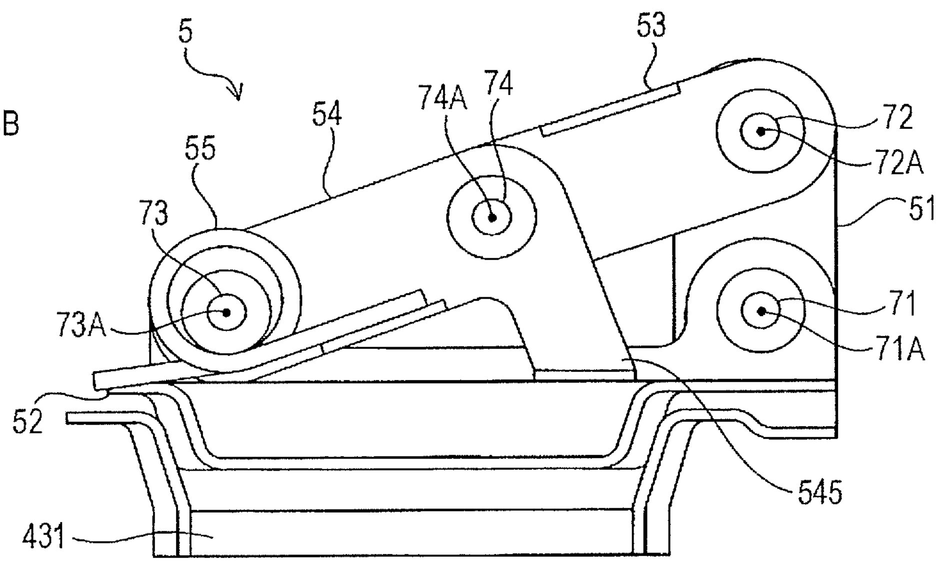

74A
5
71A,72A
73A
73
72
55
74
VIIIB
VIIIB
52
54
53
51

FIG.8B


5
53
74A
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72
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72A
73
51
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73A
71A
52
545
431

FIG.9A

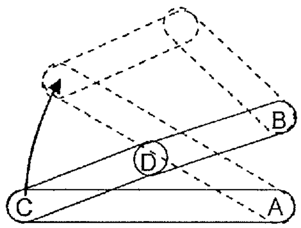


FIG.9D

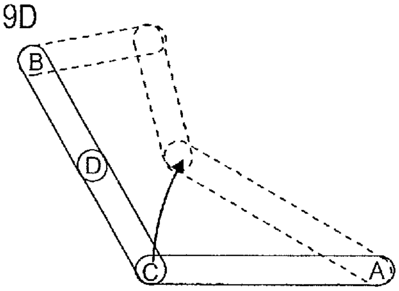


FIG.9B

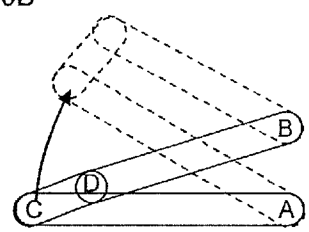


FIG.9E

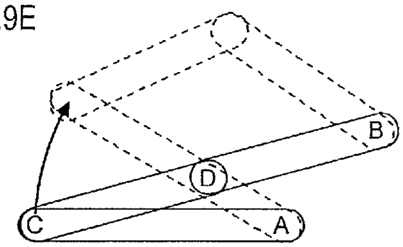


FIG.9C

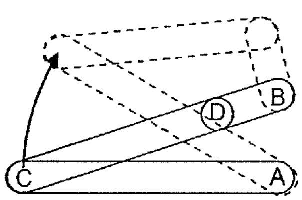
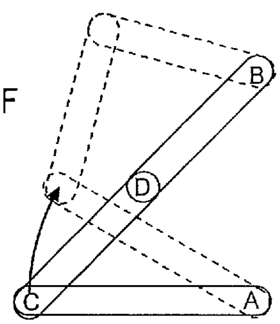


FIG.9F



VALVE DEVICE FOR EXHAUST GAS FLOW PATH

CROSS-REFERENCE TO RELATED APPLICATIONS

This international application claims the benefit of Japanese Patent Application No. 2012-037552 filed Feb. 23, 2012 in the Japan Patent Office, and the entire contents of Japanese Patent Application No. 2012-037552 are incorporated herein by reference.

TECHNICAL FIELD

The present invention relates to a valve device for an exhaust gas flow path.

BACKGROUND ART

There is known a valve device for an exhaust gas flow path to open and close a communicating flow path that communicates an upstream chamber and a downstream chamber with each other in an exhaust gas flow path for an in-vehicle internal combustion engine. In Patent Document 1 for example, there is disclosed a valve device disposed in a muffler for an internal combustion engine. An inside of the muffler is partitioned into an upstream chamber and a downstream chamber by a separator, and the valve device is provided to the separator to open and close an opening communicating the upstream chamber and the downstream chamber with each other. In the valve device, a valve body capable of closing the opening is supported by a support body so as to be rotatable about a rotation axis, and the valve body is biased in a valve closed direction by a coil spring.

When the number of revolutions of the internal combustion engine is low, an acting force exerted on the valve body by a pressure in the upstream chamber is smaller than an acting force exerted on the valve body by the sum of the biasing force of the coil spring and the pressure in the downstream chamber. Thus, the valve device is in a valve closed state in which the opening is closed. In contrast, when the number of revolutions of the internal combustion engine is increased, the acting force exerted on the valve body by the pressure in the upstream chamber becomes larger than the acting force exerted on the valve body by the sum of the biasing force of the coil spring and the pressure in the downstream chamber. Thus, the valve device is brought into a valve open state in which the valve body is spaced apart from the opening to thereby open the opening.

PRIOR ART DOCUMENTS

Patent Documents

Patent Document 1: Japanese Unexamined Patent Application Publication No. H09-195749

SUMMARY OF THE INVENTION

Problems to be Solved by the Invention

Such a valve device for an exhaust gas flow path is required to have a noise reduction function to reduce noise by closing the communicating flow path when the internal combustion engine is in a low revolution state, while being required to have a pressure loss reduction function to reduce pressure loss by opening the communicating flow path when the internal combustion engine is in a high revolution state. However, in the above-described configuration described in Patent Document 1, the more forward the valve body moves in a valve open direction, the larger the biasing force of the coil spring becomes. Therefore, when the spring force of the coil spring is designed to be stronger with an emphasis on the noise reduction function at the time of low revolution, the pressure loss reduction function at the time of high revolution is impaired. In contrast, when the spring force of the coil spring is designed to be weaker with an emphasis on the pressure loss reduction function at the time of high revolution, the noise reduction function at the time of low revolution is impaired.

In one aspect of the present invention, it is preferred for the valve device for an exhaust gas flow path to have both an improved noise reduction function at the time of low revolution and an improved pressure loss reduction function at the time of high revolution.

Means for Solving the Problems

A valve device for an exhaust gas flow path according to the present invention includes a valve body that is supported by a support body so as to be rotationally movable about a first rotation axis and that opens and closes a communicating flow path that communicates an upstream chamber and a downstream chamber in an exhaust gas flow path with each other, a first link member supported by the support body so as to be rotationally movable about a second rotation axis, a second link member supported by the valve body so as to be rotationally movable about a third rotation axis, and a biasing member to bias the valve body in a valve closed direction. The first link member and the second link member are connected to each other so as to be mutually rotationally movable about a fourth rotation axis. The first rotation axis, the second rotation axis, the third rotation axis, and the fourth rotation axis are parallel to one another in an axial direction. In a plane orthogonal to the axes, an angle formed by a first link line connecting the second rotation axis and the fourth rotation axis to each other and a second link line connecting the third rotation axis and the fourth rotation axis to each other is formed to be the largest in a state in which the communicating flow path is closed by the valve body.

According to such a configuration, the support body, the valve body, the first link member, and the second link member form a toggle mechanism of a link type. Therefore, in the state in which the communicating flow path is closed by the valve body (a valve closed state), the closer to 180 degrees (a state in which the first link line and the second link line are arranged in a straight line) the angle formed by the first link line and the second link line is, the stronger external force is required to rotationally move the valve body in a valve open direction. Accordingly, it is possible to make the external force required to open the valve body greater, while making a biasing force of the biasing member smaller, compared with a conventional configuration in which a valve body is kept in a valve closed state solely by means of a biasing member. As a result, it is possible to improve a noise reduction function at the time of low revolution of an internal combustion engine, as well as a pressure loss reduction function at the time of high revolution of the internal combustion engine.

The valve device for an exhaust gas flow path may be provided with a stopper mechanism to limit the angle formed by the first link line and the second link line to an angle smaller than 180 degrees. According to this configuration, a problem that the valve body cannot be normally opened when the angle formed by the first link line and the second link line has reached 180 degrees can be made less likely to occur.

The stopper mechanism may limit the angle formed by the first link line and the second link line to an angle smaller than 180 degrees by abutment of a first stopper portion provided on the first link member and a second stopper portion provided on the second link member against each other. According to this configuration, it is possible to reduce an influence of factors such as variations in parts dimensions and rattling of parts on a limit angle. As a result, the angle formed by the first link line and the second link line in the state in which the communicating flow path is closed by the valve body can be designed to be an angle closer to 180 degrees. Thus, it is possible to improve performance to keep a valve closed state against an external force.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a sectional view of a muffler in which a valve device is in a valve closed state.

FIG. **2**A is a plan view of the valve device according to the embodiment in a valve closed state, and FIG. **2**B is a sectional view thereof taken along line IIB-IIB.

FIG. **3**A is a plan view of the valve device according to the embodiment in a valve open state, and FIG. **3**B is a sectional view thereof taken along line IIIB-IIIB.

FIG. **4** is a sectional view of the muffler in which the valve device is in a valve open state.

FIG. **5**A is a graph showing an opening load of a butterfly valve configured in a conventional manner and an opening load of a butterfly valve configured according to the embodiment, and FIG. **5**B is a graph showing loading characteristics of a toggle mechanism and a spring.

FIG. **6**A is a plan view of a valve device according to a first modified example in a valve closed state, and FIG. **6**B is a sectional view thereof taken along line VIB-VIB.

FIG. **7**A is a plan view of a valve device according to a second modified example in a valve closed state, and FIG. **7**B is a sectional view thereof taken along line VIIB-VIIB.

FIG. **8**A is a plan view of a valve device according to a third modified example in a valve closed state, and FIG. **8**B is a sectional view thereof taken along line VIIIB-VIIIB.

FIG. **9**A is a schematic diagram showing an example of a toggle mechanism in which a relationship BD=CD is satisfied. FIG. **9**B is a schematic diagram showing an example of a toggle mechanism in which a relationship BD>CD is satisfied. FIG. **9**C is a schematic diagram showing an example of a toggle mechanism in which a relationship BD<CD is satisfied. FIG. **9**D is a schematic diagram showing an example of a toggle mechanism in which a position of a point B lies outside an arc-shaped movement locus of a point C. FIG. **9**E is a schematic diagram showing an example of a toggle mechanism in which a position of a point B lies in a position where an angle formed by a line segment AB and a line segment AC is greater than 90 degrees. FIG. **9**F is a schematic diagram showing an example of a toggle mechanism in which a position of a point B lies in a position where a relationship AB>AC is satisfied.

EXPLANATION OF REFERENCE NUMERALS

1 . . . muffler, **5** . . . valve device, **10** . . . casing, **31** . . . first chamber, **32** . . . second chamber, **33** . . . third chamber, **41** . . . inlet pipe, **42** . . . outlet pipe, **43** . . . inner pipe, **51** . . . stay, **52** . . . butterfly valve, **53** . . . first link member, **54** . . . second link member, **55** . . . spring, **71** . . . first rotation axis member, **71**A . . . first rotation axis, **72** . . . second rotation axis member, **72**A . . . second rotation axis, **73** . . . third rotation axis member, **73**A . . . third rotation axis, **74** . . . fourth rotation axis member, **74**A . . . fourth rotation axis, **221** . . . communication hole, **411** . . . through-holes, **431** . . . opening, **531** . . . first stopper portion, **541** . . . second stopper portion, L**1** . . . first link line, L**2** . . . second link line

MODE FOR CARRYING OUT THE INVENTION

An embodiment to which the present invention is applied is described below with reference to the drawings.

A muffler **1** shown in FIG. **1** forms a part of an exhaust gas flow path through which flows an exhaust gas discharged from an in-vehicle internal combustion engine (not shown). The muffler **1** includes a casing **10**, in which openings at both ends of a cylindrical shell member **11** are closed by a rear lid member **12** and a front lid member **13**. An inside of the casing **10** is partitioned into three chambers, i.e., a first chamber **31**, a second chamber **32**, and a third chamber **33** by a first separator **21** and a second separator **22**.

The first chamber **31** is provided between the rear lid member **12** and the first separator **21**. The second chamber **32** is provided between the first separator **21** and the second separator **22**. The third chamber **33** is provided between the second separator **22** and the front lid member **13**. The second separator **22** has a communication hole **221** provided therein that communicates the second chamber **32** and the third chamber **33** with each other.

The muffler **1** further includes an inlet pipe **41** through which the exhaust gas from the internal combustion engine is introduced. The inlet pipe **41** is provided so as to penetrate through the front lid member **13**, the second separator **22**, and the first separator **21** and to open to the first chamber **31** at its downstream-side end. Provided in an outer periphery of the inlet pipe **41** in the second chamber **32** are a plurality of through-holes **411** that communicate an internal space of the inlet pipe **41** and the second chamber **32** with each other.

The muffler **1** further includes an outlet pipe **42** to be connected to a not-shown tailpipe to discharge the exhaust gas. The outlet pipe **42** is provided so as to penetrate through the rear lid member **12**, the first separator **21**, and the second separator **22** and to open to the third chamber **33** at its upstream-side end.

The muffler **1** further includes an inner pipe **43** to form a communicating flow path that communicates the first chamber **31** and the third chamber **33** with each other. The inner pipe **43** is provided so as to penetrate through the first separator **21** and the second separator **22**, to open to the first chamber **31** at its upstream-side end, and to open to the third chamber **33** at its downstream-side end. However, in the third chamber **33**, the inner pipe **43** has, at the downstream-side end thereof, a valve device **5** mounted to open and close an opening **431** provided at the downstream-side end of the inner pipe **43**.

As shown in FIGS. **2**A, **2**B, **3**A, and **3**B, the valve device **5** includes a stay **51**, a butterfly valve **52**, a first link member **53**, and a second link member **54**. The stay **51** is fixed in position with respect to the opening **431** provided at the downstream-side end of the inner pipe **43**. Each of the butterfly valve **52** and the first link member **53** is supported at one end thereof by the stay **51**. The second link member **54** is supported at one end thereof by the butterfly valve **52**.

The butterfly valve **52** is shaped so as to be able to close the opening **431** of the inner pipe **43**, and is connected at an end thereof to the stay **51** via a first rotation axis member **71**.

Specifically, the butterfly valve **52** is supported by the stay **51** so as to be rotationally movable about a rotation axis (hereinafter referred to as a "first rotation axis **71**A") of the first rotation axis member **71**, and opens and closes the opening **431** of the inner pipe **43** according to its rotational position.

The first link member **53** is connected at an end thereof to the stay **51** via a second rotation axis member **72**. Specifically, the first link member **53** is supported by the stay **51** so as to be rotationally movable about a rotation axis (hereinafter referred to as a "second rotation axis **72**A") of the second rotation axis member **72**.

The second link member **54** is connected at an end thereof to an upper surface (a portion that stands up with valve opening) of the butterfly valve **52** via a third rotation axis member **73**. Specifically, the second link member **54** is supported by the butterfly valve **52** so as to be rotationally movable about a rotation axis (hereinafter referred to as a "third rotation axis **73**A") of the third rotation axis member **73**.

The first link member **53** and the second link member **54** are connected to each other via a fourth rotation axis member **74**. Specifically, the first link member **53** and the second link member **54** are connected to each other so as to be mutually rotationally movable about a rotation axis (hereinafter referred to as a "fourth rotation axis **74**A") of the fourth rotation axis member **74**. The first rotation axis **71**A, the second rotation axis **72**A, the third rotation axis **73**A, and the fourth rotation axis **74**A are parallel to one another in an axial direction.

Due to such a configuration, the stay **51**, the butterfly valve **52**, the first link member **53**, and the second link member **54** form a toggle mechanism of a link type. The butterfly valve **52** is rotationally movable from a valve closed state (FIGS. **2**A and **2**B) in which the opening **431** of the inner pipe **43** is closed to a valve open state (FIGS. **3**A and **3**B) in which the opening **431** of the inner pipe **43** is open.

The valve device **5** further includes a spring **55** to bias the butterfly valve **52** in a valve closed direction. The spring **55** is mounted to the third rotation axis member **73**, and applies a biasing force in a direction to bring the butterfly valve **52** and the second link member **54** closer to a positional relationship (angle) in a valve closed state. Accordingly, in its regular state (a state in which no external force to open the butterfly valve **52** is applied), the butterfly valve **52** is in a valve closed state.

The first link member **53** and the second link member **54** are designed to be arranged in an approximately straight line in a valve closed state. In other words, in a plane orthogonal to the first rotation axis **71**A, an angle θ formed by a first link line L**1** connecting the second rotation axis **72**A (specifically, an intersection between the axis and the plane, and the same applies hereafter) and the fourth rotation axis **74**A to each other and a second link line L**2** connecting the third rotation axis **73**A and the fourth rotation axis **74**A to each other is an angle close to 180 degrees in a valve closed state (FIGS. **2**A and **2**B). It is designed so that the angle θ becomes smaller as the butterfly valve **52** is rotationally moved in a valve open direction (FIGS. **3**A and **3**B), and the angle θ in a valve closed state is formed to be the largest. Accordingly, in a valve closed state, a strong external force is required to rotationally move the butterfly valve **52** in the valve open direction.

Further provided in the valve device **5** is a stopper mechanism to limit the angle θ formed by the first link line L**1** and the second link line L**2** to an angle smaller than 180 degrees. Specifically, the stopper mechanism includes a first stopper portion **531** provided on the first link member **53** and a second stopper portion **541** provided on the second link member **54**. The angle θ formed by the first link line L**1** and the second link line L**2** is limited to an angle smaller than 180 degrees by abutment of the first stopper portion **531** and the second stopper portion **541** against each other.

In the present embodiment, the first link member **53** includes side plate portions **532** and **533** provided on its both sides in an axial direction, and a coupling plate portion **534** coupling the side plate portions **532** and **533** to each other. Similarly, the second link member **54** includes side plate portions **542** and **543** provided on its both sides in an axial direction, and a coupling plate portion **544** provided on its both sides in an axial direction, and a coupling plate **544** coupling the side plate portions **542** and **543** to each other. Furthermore, it is configured such that the coupling plate portion **534** of the first link member **53** and the side plate portions **542** and **543** of the second link member **54** abut against each other. That is, the coupling plate portion **534** of the first link member **53** functions as the first stopper portion **531**, and the side plate portions **542** and **543** of the second link member **54** function as the second stopper portion **541**.

Next, an explanation will be given about an action of the valve device **5**. The exhaust gas from the internal combustion engine is introduced into the second chamber **32** via the plurality of through-holes **411** formed in the inlet pipe **41**, as indicated by arrows in FIG. **1**, and noise is silenced by an expansion effect and a resonance effect. Subsequently, the exhaust gas in the second chamber **32** is introduced into the third chamber **33** via the communication hole **221** formed in the second separator **22**, and noise is further silenced by an expansion effect and a resonance effect. In this way, the exhaust gas in the third chamber **33**, pressure pulsation of which has been smoothed and noise of which has been silenced, is discharged to the outside via the outlet pipe **42**.

Here, when a pressure in the first chamber **31** is still low, e.g., when the number of revolutions of the internal combustion engine is low, a pressure difference between that in the first chamber **31** and that in the third chamber **33** is small. At this time, an acting force exerted on the butterfly valve **52** of the valve device **5** by the pressure in the first chamber **31** is smaller than an acting force exerted on the butterfly valve **52** of the valve device **5** by a load applied by the toggle mechanism and the spring **55** in the valve device **5** and the pressure in the third chamber **33**. Accordingly, the opening **431** of the inner pipe **43** is closed by the butterfly valve **52**.

In contrast, when operating conditions of the internal combustion engine have changed and, for example, when the number of revolutions of the internal combustion engine is increased to increase an amount of the exhaust gas and the pressure is increased to a predetermined pressure, the acting force exerted on the butterfly valve **52** of the valve device **5** by the pressure in the first chamber **31** becomes larger than the acting force exerted on the butterfly valve **52** of the valve device **5** by the load applied by the toggle mechanism and the spring **55** in the valve device **5** and the pressure in the third chamber **33**. As a result, as shown in FIG. **4**, the butterfly valve **52** is spaced apart from the opening **431** of the inner pipe **43** against the latter acting force to open the opening **431**, and the first chamber **31** and the third chamber **33** thereby communicate with each other via the inner pipe **43**.

In this way, the opening **431** of the inner pipe **43** is opened and a communicating flow path (a bypass flow path) is formed separately when the pressure in the first chamber **31** is increased to the predetermined pressure or more, and thus, even when an amount of the exhaust gas introduced into the first chamber **31** is increased, such exhaust gas is promptly discharged to the third chamber **33**. Consequently, the pressure in the first chamber **31** is not increased, and even when the pressure of the exhaust gas from the internal combustion engine is increased, an increase in back pressure thereof can be suppressed. Furthermore, even when a flow rate of the exhaust gas is increased, an increase in pressure in the muffler **1** can be suppressed and, thus, airflow noise is reduced.

As described above, in the valve device **5** according to the present embodiment, the stay **51**, the butterfly valve **52**, the first link member **53**, and the second link member **54** form the toggle mechanism of a link type. Since the angle θ formed by the first link line L**1** and the second link line L**2** in a valve closed state is an angle close to 180 degrees, a strong external force is required to rotationally move the butterfly valve **52** in the valve open direction. Accordingly, it is possible to make the external force required to open the butterfly valve **52** greater, while weakening a biasing force of the spring **55**, compared with a conventional configuration in which a butterfly valve is kept in a valve closed state solely by means of a spring. That is, it is possible to reduce a load to keep the butterfly valve **52** in a valve open state, while increasing a load to bring the butterfly valve **52** from a valve closed state to a valve open state. Consequently, it is possible to reduce pressure loss at the time of high revolution of the internal combustion engine, while reducing noise by improving air-tightness at the time of low revolution or initial explosion of the internal combustion engine. In addition, a striking noise made when the butterfly valve **52** is closed can be reduced because the biasing force of the spring **55** can be weakened.

Specifically, as shown in FIG. **5**A, in the conventional configuration in which a butterfly valve is kept in a valve closed state solely by means of a spring, the larger a degree of opening (an opening amount) of the butterfly valve is, the larger a moment (an opening load at the time when the butterfly valve is pushed in a direction in which the exhaust gas flows) becomes (a broken line L**1**). In contrast, in the configuration according to the present embodiment, in which the butterfly valve **52** is kept in a valve closed state by means of the toggle mechanism and the spring **55**, a moment at the time when the butterfly valve **52** starts opening becomes larger (a solid line L**2**). That is, as shown in FIG. **5**B, the spring **55** has linear characteristics such that the larger the degree of opening of the butterfly valve **52** is, the larger the moment becomes (a broken line L**3**), and the toggle mechanism has characteristics such that the moment becomes largest when the butterfly valve **52** is in a valve closed state (a solid line L**4**). Therefore, in the configuration according to the present embodiment, in which the butterfly valve **52** is kept in a valve closed state by means of the toggle mechanism and the spring **55**, it is possible to decrease the moment in a state in which the degree of opening of the butterfly valve **52** is larger, while increasing the moment in a state in which the degree of opening is smaller.

Since the valve device **5** has the stopper mechanism provide therein, a problem that the butterfly valve **52** cannot be normally opened when the angle θ formed by the first link line L**1** and the second link line L**2** has reached 180 degrees can be made less likely to occur. Such a stopper mechanism is especially effective to make the angle θ formed by the first link line L**1** and the second link line L**2** in a valve closed state closer to 180 degrees. This is because it is assumed that the closer to 180 degrees the angle θ in a valve closed state is, the more likely an actually formed angle under the influence of variations in parts dimensions, rattling of parts, or the like reaches 180 degrees.

Especially, the stopper mechanism according to the present embodiment is provided to the first link member **53** and the second link member **54** themselves that form the first link line L**1** and the second link line L**2**, respectively, and thus, it is possible to reduce the influence of factors such as variations in parts dimensions and rattling of parts on a limit angle. As a result, the angle θ in a valve closed state can be designed to be an angle closer to 180 degrees, and a configuration with high performance to keep a valve closed state against an external force can be achieved.

The first chamber **31** corresponds to an example of an upstream chamber, and the third chamber **33** corresponds to an example of a downstream chamber. The valve device **5** corresponds to an example of a valve device for an exhaust gas flow path, the stay **51** corresponds to an example of a support body, the butterfly valve **52** corresponds to an example of a valve body, the first link member **53** and the second link member **54** correspond to an example of a first link member and a second link member, respectively, and the spring **55** corresponds to an example of a biasing member. The first rotation axis **71**A to the fourth rotation axis **74**A correspond to an example of a first rotation axis to a fourth rotation axis, respectively, and the first link line L**1** and the second link line L**2** correspond to an example of a first link line and a second link line, respectively.

The embodiment of the present invention has been described hereinabove. However, it is to be appreciated that the present invention is not limited to the above-described embodiment and can take various forms.

(1) In the above-described embodiment, as a biasing device to bias the butterfly valve **52** in the valve closed direction, the spring **55** to apply a biasing force in a direction to bring the butterfly valve **52** and the second link member **54** closer to a positional relationship (angle) in a valve closed state is exemplified. However, the biasing device is not limited to this. As shown in FIGS. **6**A and **6**B for example, a configuration may be adopted in which the spring **55** is mounted to the fourth rotation axis member **74** and a biasing force is applied in a direction to bring the first link member **53** and the second link member **54** closer to a positional relationship (angle) in a valve closed state. Alternatively, as shown in FIGS. **7**A and **7**B for example, a configuration may be adopted in which the spring **55** is mounted to the second rotation axis member **72** and a biasing force is applied in a direction to bring the stay **51** and the first link member **53** closer to a positional relationship (angle) in a valve closed state.

(2) In the above-described embodiment, the stopper mechanism configured such that the first stopper portion **531** provided on the first link member **53** and the second stopper portion **541** provided on the second link member **54** abut against each other is exemplified. However, the stopper mechanism is not limited to this. As shown in FIGS. **8**A and **8**B for example, a configuration may be adopted in which the angle θ formed by the first link line L**1** and the second link line L**2** is limited to an angle smaller than 180 degrees by abutment of a protruding portion **545** formed in the second link member **54** against the upper surface of the butterfly valve **52**.

(3) A positional relationship of the first rotation axis **71**A to the fourth rotation axis **74**A with respect to one another is not limited to that exemplified in the above-described embodiment. As shown in FIGS. **9**A to **9**F for example, various positional relationships can be adopted. In these

figures, points at the intersections of the first rotation axis **71**A to the fourth rotation axis **74**A with the plane orthogonal to these axes are referred to as A to D, respectively. In each of these figures, a valve closed state is shown with a solid line, and a valve open state is shown with a broken line.

For example, a relationship between a line segment BD (a length of the first link line L**1**) and a line segment CD (a length of the second link line L**2**) may be BD=CD as shown in FIG. **9**A, may be BD>CD as shown in FIG. **9**B, or may be BD<CD as shown in FIG. **9**C.

As shown in FIG. **9**D, a position of a point B (a position of the second rotation axis **72**A) may lie outside an arc-shaped movement locus of a point C. As shown in FIG. **9**E, a position of a point B may lie in a position where an angle formed by a line segment AB and a line segment AC is larger than 90 degrees. As shown in FIG. **9**F, a position of a point B may lie in a position where a relationship AB>AC is satisfied.

(4) In the above-described embodiment, the configuration in which the valve device **5** is mounted to the inner pipe **43** at the downstream-side end thereof is exemplified. However, a position where the valve device **5** is mounted is not limited to this. For example, the valve device **5** may be mounted to a through-hole provided in the second separator **22**.

The invention claimed is:

1. A valve device for an exhaust gas flow path, the device comprising: a support body; a valve body that is supported by the support body so as to be rotationally movable about a first rotation axis and that opens and closes a communicating flow path that communicates an upstream chamber and a downstream chamber in an exhaust gas flow path with each other; a first link member supported by the support body so as to be rotationally movable about a second rotation axis; a second link member supported by the valve body so as to be rotationally movable about a third rotation axis; and a biasing member to bias the valve body in a valve closed direction, wherein the first link member and the second link member are connected to each other so as to be mutually rotationally movable about a fourth rotation axis, wherein the first rotation axis, the second rotation axis, the third rotation axis, and the fourth rotation axis are parallel to one another in an axial direction, wherein, in a plane orthogonal to the axes, an angle formed by a first link line connecting the second rotation axis and the fourth rotation axis to each other and a second link line connecting the third rotation axis and the fourth rotation axis to each other is formed largest in a state in which the communicating flow path is closed by the valve body, a stopper mechanism to limit the angle formed by the first link line and the second link line, and wherein a distance between the first rotation axis and the third rotation axis is longer than a distance between the second rotation axis and the fourth rotation axis.

2. The valve device for an exhaust gas flow path according to claim **1**, wherein the stopper mechanism limits the angle formed by the first link line and the second link line by abutment of a first stopper portion provided on the first link member and a second stopper portion provided on the second link member against each other.

3. The valve device for an exhaust gas flow path according to claim **1**, wherein the stopper mechanism limits the angle formed by the first link line and the second link line to an angle smaller than 180 degrees.

4. The valve device for an exhaust gas flow path according to claim **1**, wherein, in the plane orthogonal to the axes, the angle formed by the first link line and the second link line is an angle close to 180 degrees in the state in which the communicating flow path is closed by the valve body.

5. The valve device for an exhaust gas flow path according to claim **1**, wherein the third rotation axis is positioned at a leading end side of the valve body.

6. The valve device for an exhaust gas flow path according to claim **1**, wherein a distance between the first rotation axis and the third rotation axis is longer than a distance between the third rotation axis and the fourth rotation axis.

7. The valve device for an exhaust gas flow path according to claim **1**, wherein a distance between the first rotation axis and the third rotation axis is longer than a distance between the first rotation axis and the second rotation axis.

8. The valve device for an exhaust gas flow path according to claim **1**, wherein, in the state in which the communicating flow path is closed by the valve body, in the plane orthogonal to the axes, the angle formed by the first link line and the second link line is larger than an angle formed by a line connecting the second rotation axis and the first rotation axis to each other and a line connecting the third rotation axis and the first rotation axis to each other.

9. The valve device for an exhaust gas flow path according to claim **1**,

wherein the biasing member is mounted to a rotation axis member which is movable about the third rotation axis, and biases the valve body in the valve closed direction by applying a biasing force in a direction to bring the valve body and the second link member closer to an angle in a valve closed state.

10. The valve device for an exhaust gas flow path according to claim **1**, wherein the biasing member is mounted to a rotation axis member which is movable about the fourth rotation axis, and biases the valve body in the valve closed direction by applying a biasing force in a direction to bring the first link member and the second link member closer to an angle in a valve closed state.

11. The valve device for an exhaust gas flow path according to claim **2**, wherein the stopper mechanism limits the angle formed by the first link line and the second link line to an angle smaller than 180 degrees.

12. The valve device for an exhaust gas flow path according to claim **3**, wherein, in the plane orthogonal to the axes, the angle formed by the first link line and the second link line is an angle close to 180 degrees in the state in which the communicating flow path is closed by the valve body.

13. The valve device for an exhaust gas flow path according to claim **4**, wherein the third rotation axis is positioned at a leading end side of the valve body.

14. The valve device for an exhaust gas flow path according to claim **1**, wherein, in the plane orthogonal to the axes, the first link line and the second link line are configured to be arranged in an approximately straight line in the state in which the communicating flow path is closed by the valve body.

15. The valve device for an exhaust gas flow path according to claim **1**, wherein the stopper mechanism is configured to prevent an angle formed by the first link line and the second link line from reaching 180 degrees.

16. The valve device for an exhaust gas flow path according to claim **1**, wherein the third rotation axis is positioned at an end of the valve body opposite to an end where the first rotation axis is positioned.

17. The valve device for an exhaust gas flow path according to claim **2**, wherein each of the first link member and the second link member comprise two side plate portions on both sides thereof in an axial direction, and a coupling plate portion that couples the two side plate portions, wherein, by an abutment of the coupling plate portion of the first link member and the two side plate portions of the second link member, the stopper mechanism limits an angle formed by the first link line and the second link line.

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